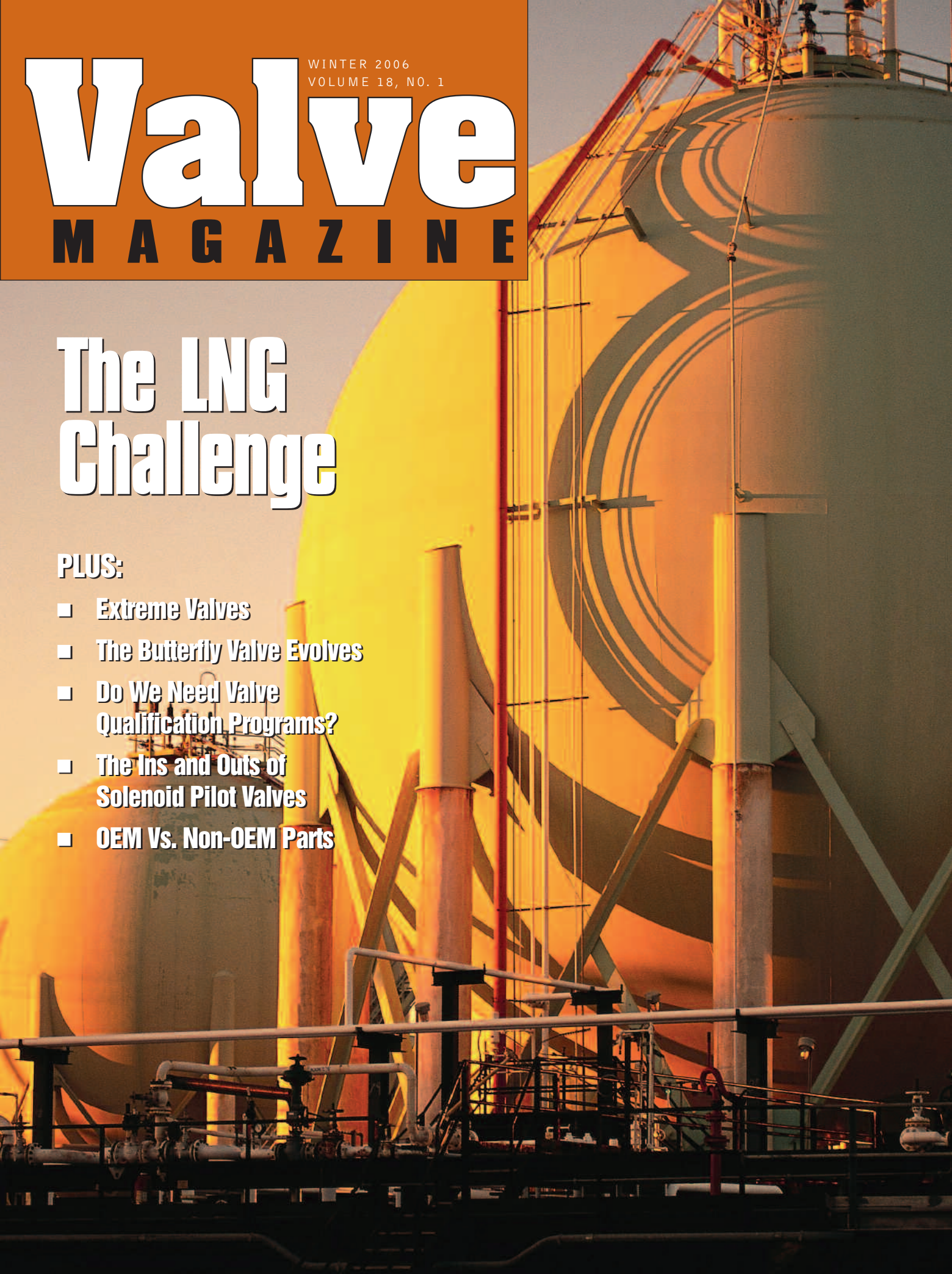
WINTER 2006
VOLUME 18, NO. 1

Valve MAGAZINE



The LNG Challenge

PLUS:

- Extreme Valves
- The Butterfly Valve Evolves
- Do We Need Valve Qualification Programs?
- The Ins and Outs of Solenoid Pilot Valves
- OEM Vs. Non-OEM Parts

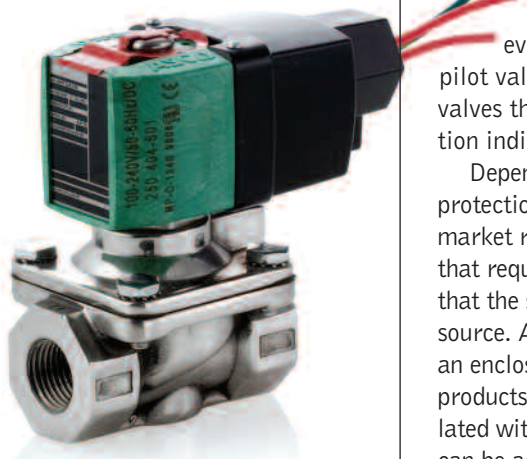
SOLENOID PILOT VALVES FOR VALVE ACTUATION

KNOWING THE INS AND OUTS OF PILOT VALVES WILL HELP USERS SELECT THE CORRECT PILOT VALVE CONSTRUCTION FOR AN APPLICATION.

BY BILL REESON

The term "pilot valve" is used in reference to a three- or four-way solenoid valve that pilots or controls the flow of media, such as air or water, into an actuator, which in turn controls the movement of a valve connected to the actuator. In other words, the pilot valve drives or controls the main process or control valve in a process control system.

To meet specific customer needs, pilot valves are available in a multitude of variations. Electrically, they vary by voltage, power consumption, and method of protection. Most solenoids can be designed for use in almost any voltage, whether it's AC or DC. The trend in the market is toward DC because of increased use of distributed control systems and bus protocols. The only drawback in using DC is that most solenoid valves in DC valves cannot operate at the same pressure as their AC equivalents. However, some manufacturers now have technology that permits the same pressure rating whether the valve is AC or DC. In fact, solenoid coil technology has improved so much that a customer can purchase one valve and operate it over a given voltage range such as 100 to 240 at 50 to 60Hz in AC or DC.



Valve with a voltage ranging coil

Design Challenges

Over the past decade, one of the biggest challenges of solenoid design has been minimizing power consumption. This is especially true for pilot valves. The increased use of distributed controls systems and bus protocols has meant the average solenoid power consumption in DC voltage has dropped from a level of 10 watts to 1.5 watts. The less power consumed, the smaller and less expensive a power supply need be. Bus protocols are demanding more stringent power levels than ever. The less power consumed over a bus network, the more nodes or slave devices are possible over that network. If the protocol is powering the solenoid directly off the bus, power restrictions are limited from 0.5 watts to as low as 1.4 milliamps, depending on the type of network. As soon as the power consumption drops to the milliamp range, the technology shifts from a typical electromagnetic circuit solenoid to a piezo or constant bleed device. Powering the pilot valve directly off the bus via a position indicator gives the user less wiring since only one cable is connected from node to node, eliminating the need to run a separate cable to each device from a PLC. This one cable transmits data and power. To use a pilot valve that cannot be powered off of the bus would require an external power supply from the bus and in many cases a different node device that will allow use of an external power supply. Pilot valves that can be used as individual nodes or slave devices over certain network protocols are also available. However, they are not as common because most pilot valves used over networks are standard pilot valves that serve as an output device from a position indicator.

Piezo-operated pilot valve for use as a Foundation fieldbus or Profibus PA output device

Depending on the environment, many methods of protection are used. A large part of the process control market requires explosion-proof equipment. To meet that requirement, the pilot can be designed using intrinsic safety in such a manner that the solenoid cannot cause a spark or generate sufficient heat to create an ignition source. Another protection method is to contain possible sparks or explosions within an enclosure that will not allow flame to propagate to the outside atmosphere. These products either have the explosion-proof enclosure or use electronics that are encapsulated with some type of potting compound. Third-party approval for these protections can be achieved, depending on where the customer is located.

Pilot Valve Functions

Pilot valve function has typically been either three- or four-way. Today there are many functions based on these two basic descriptions, and it is not uncommon to see descriptions such as 3/2 NC, 3/2 NO, 3/2 U, 3/3, 4/2, 5/2, and 5/3. While these designations may look confusing, they are actually quite simple. For a three-way pilot valve, for example, the expression 3/2 NC means:

- The number 3 signifies three ports on the valve.
- The number 2 designates that the valve has two positions. The two positions are energized or de-energized.
- NC stands for normally closed, which means that in the de-energized position, the process connection to the actuator is closed.

The first port is normally marked as P (pressure) or 1. This is the air supply to the valve. The second port is C (cylinder) or 2. This is the working port connected to the piston side of a spring-return actuator. The third port is designated 3 or E (exhaust). The exhaust port is where the air from the actuator is released when the pilot valve changes state from energized to de-energized.

Sometimes there is another port on a 3/2 pilot valve. This most likely will be designated as R, which stands for re-breather—the port connected to the spring side of a spring-return actuator. As the air being exhausted travels out of the piston side of the actuator, the re-breather port channels it into the spring side. This keeps outside air from being ingested into the spring side of the actuator, giving that actuator some environmental protection from anything in the atmosphere that may corrode internal parts.

Four-way pilot valves typically are used for double-acting actuators. A pilot valve designated 4/2 is a four-way valve with four ports. It consists of an air supply, designated 1 or P; two cylinder or working ports, designated ports 2 and 4, or A and B; and a common exhaust port for both of the working ports, designated 3 or E.

A 5/2 valve is a four-way valve that has five ports designated as follows: Port 1 is the air inlet or pressure port, ports 2 and 4 are the cylinder or working ports, and ports 3 and 5 are the exhausts. Port 3 is the exhaust for port 2 and port 5 is the exhaust for port 4. Each cylinder port has its own exhaust so you can add flow controllers to the exhaust ports to control the opening or closing speed of the actuator that the pilot valve controls.

Single or Dual Solenoids

All the constructions described above are available with a single solenoid or dual solenoids. The single-solenoid versions normally have a spring return so the valve automatically returns to its normal state during power loss. The dual-solenoid versions remain in the last position when power is lost.

With the dual-solenoid versions, there are constructions designated as 3/3 and 5/3. Again, the second number designates number of positions. The positions are the following: de-energized or center position; solenoid A energized; and solenoid B energized. In this dual-solenoid construction, the center position is the only position that is different. Typically, this center position is called "center open," where all of the cylinder ports to exhaust are open, or "center closed," where all of the ports are closed. The center position can be made to accommodate almost any function—depending on customer needs—that the pilot valve design will allow. The majority of pilot valves for this function are spool valves used for keeping the actuator from moving from its position during power loss.

Mounting Configurations

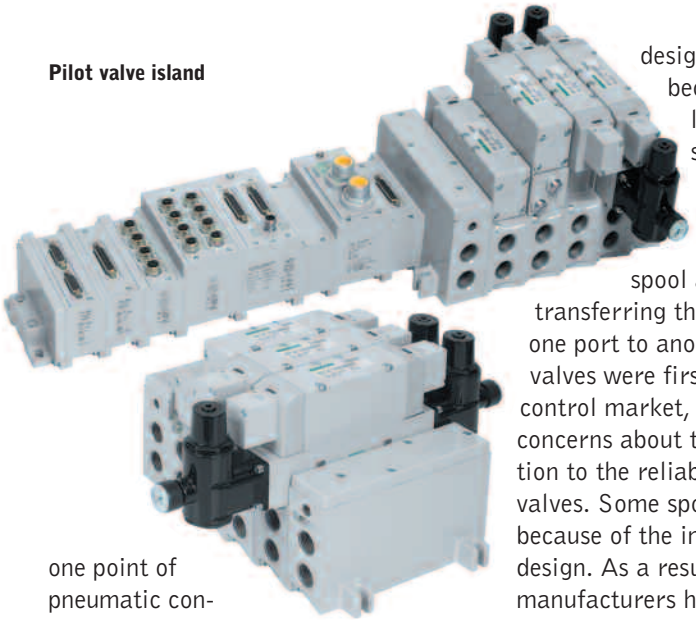
Pilot valves also are available in many mounting configurations. The most common are piped, NAMUR-mounted, pilot valve islands, and pilot valves integrated into a position indicator or integrated as part of the actuator itself. The overwhelming majority of pilot valves sold each year are piped. However, the other configurations are rapidly growing in use.

NAMUR mount valve

Perhaps the fastest growing configuration is the NAMUR standard mounting, which started in Europe more than two decades ago. This standard allows the customer to save on piping costs because the pilot valve can be attached to the actuator without the need for piping. The only pipe needed is for air supply to the valve. As actuator manufacturers accepted this standard, so too have pilot valve companies. The two sizes for the NAMUR mounting for pilot valves are 1/4-inch and 1/2-inch standards. The 1/2-inch is not as common right now, but actuators and pilot valves in this size are available, as are the more common 1/4-inch NAMUR standard for control valve applications. The difference between this standard and the normal 1/4-inch standard is a port included for external pilot air.

Pilot Valve Islands

The pharmaceutical industry uses pilot valve islands (or manifolds), where the primary function is the actuation of sanitary valves. Since the ingress protection and approvals of these types of valves are limited, pilot valve islands are mounted inside an enclosure. All the electronics reside in the enclosure, and tubing runs from the enclosure to each point of actuation. A benefit of these islands is that the pilot valves usually are in one location, with one point of electrical connection as well as



Pilot valve island

one point of pneumatic connection for the supply. Pilot valves built into or attached to a position indicator are very common today. Typically, the pilot valve is connected to a position indicator via conduit, so it makes sense to integrate these two pieces of hardware into one. This approach gives the customer a savings in electrical hookup costs and generally saves space on the overall assembly.

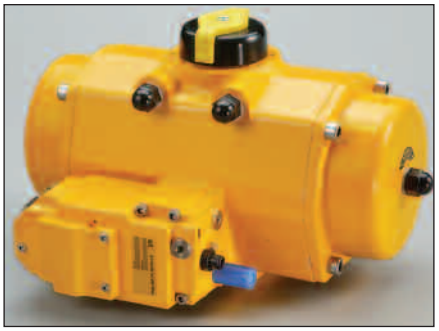
Pilot valves integrated into actuators also are available. These combine the functions of an actuator, position indicator, and solenoid pilot valve in one unit, an approach used by some actuator manufacturers to supply one turnkey solution for the entire assembly. All that is needed is one electrical connection and one pneumatic connection.

Basic Construction: Poppet or Spool

The basic construction of a pilot valve is either poppet or spool, which refers to the actual internal workings of a pilot valve that diverts air from the pressure port to the cylinder and the cylinder to exhaust. In the past, most pilot valves were poppet construction. Poppet-style pilot valves consist of an elastomeric disc that opens and closes and an orifice—a very simple and reliable approach to controlling the flow of a fluid.

The individual pilot valves found in valve island applications are of spool design, which is popular because it is generally less expensive to construct. One spool slides through a series of O-rings. Grooves machined into the spool act as flow passages, transferring the flow of the air from one port to another. When spool valves were first used in the process control market, some customers had concerns about the relationship of friction to the reliability of these pilot valves. Some spool valves did not shift because of the inherent friction of the design. As a result, some pilot valve manufacturers have conducted extensive product development to overcome this.

Generally, customers prefer one valve construction over another. Many like the poppet-style valve because movement is in direct relationship to the movement of the solenoid armature. These direct-acting pilot valves do not require minimum air pressure to operate. For this reason, this style of valve is used to operate dome-actuated control valves that operate between 0-15 psi. Spool valves are considered indirect-acting valves, since they require a minimum amount of air pressure to cause the spool to move. Actually, most spool-type pilot valves are operated by a small, three-way, direct-acting valve that transfers air pressure to a piston, which then pushes the spool and causes movement. Indirect-acting valves can be used on control valve applications as well, but the valve must have an external pilot connection. Air pressure sufficient to shift the valve is connected to the external pilot connection, while the main valve body controls the flow of low pressure air into the control valve.



Actuator with built-in position indicator and solenoid valve

Redundant solenoid system for reliability and safety

Safety and Reliability Concerns

Safety and reliability also have been the focus of industry concern. Over the years, pilot valves used in many applications were for systems designed by an assembler or end user. The end user would pipe up two solenoid valves together so that if one of them were to de-energize unexpectedly, the other valve would keep the process from shutting down prematurely. This may be a reliable solution, but it is not necessarily safe. If the system is asked to shut down, the risk doubles because two solenoids are closing. Today, users can purchase a complete pilot valve system that will operate with the redundancy needed to keep the process running, but that will also shut down upon request. Such systems can test the solenoid valves as well as partial stroke to test the process valve for system integrity.

To correctly fit a customer's application, many aspects of pilot valves must be considered. Most solenoid valve manufacturers have customer support personnel and distribution networks to help users select the correct pilot valve construction for their applications. **VM**

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